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Conference on Elementary Processes  
in Radiation Chemistry, Notre Dame  
April 4-7, 1972

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### Dissociative Electron Attachment to Dimethylether in Irradiated 3-Methylpentane Glass

Hiroshi YOSHIDA, Masahiro IRIE, Osamu SHIMADA  
and Koichiro HAYASHI

Division of Industrial Physical Chemistry

The trapped electron in gamma-irradiated 3-methylpentane glass containing dimethylether shows an esr spectrum of width 3.7 G and an optical absorption band with a maximum at 1250 nm. It is bleached with light of wavelength shorter than 1170 nm. The photobleaching is followed by the formation of methyl radical. The conversion efficiency from a trapped electron to a methyl radical is found to be *independent* of the wavelength in the range examined (1170-600 nm). All experimental results indicated that the methyl radical is formed by dissociative electron attachment to dimethylether which occurs only when the trapped electron is photobleached but not occurs during gamma-irradiation.

According to gas phase data, the reaction is expected to be endothermic by about 0.7 eV, although this value may be decreased somewhat in the glassy matrix. Therefore, the results seem to lead to the amazing conclusion that all electrons detrapped by light have an appreciable amount of kinetic energy independent of the photon energy of the light.

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American Chemical Society Boston,  
April 10-14, 1972

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### Polymerization of Tetraoxane in the Solid State

Akihiko ITO\*, Yoshiaki NAKASE\*, Masaru YOSHIDA\*,  
Masahiro SAKAMOTO\* and Koichiro HAYASHI

Division of Industrial Physical Chemistry

The radiation-induced post polymerization of tetraoxane was studied. A higher polymer yield was obtained in air than in vacuo, and in addition, a striking decrease in the molecular weight of polymer was observed in air. In order to clarify whether this decrease was due to the degradation of polymer formed or due to the formation of low molecular weight polymers, fractionation of polymer by the mechanical agitation method was conducted.

Free radical initiators such as benzoyl peroxide, di-tertbutyl peroxide and  $\alpha$ ,  $\alpha'$ -

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azobisisobutyronitrile polymerized tetraoxane in the solid state in the presence of oxygen, but no polymer was obtained in vacuo. A possible initiation mechanism was thought as charge transfer from tetraoxane radical to oxygen molecule.

The solid state polymerization of tetraoxane was also initiated by electron acceptors such as tetracyanoethylene, maleic anhydride or trinitrobenzene.

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The Fifth International Colloquium  
on Magnetic Thin Films, April 16-  
19, 1972

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### **Magnetic Aging of Electrodeposited Ni-Fe-P Thin Films**

Kôichi MUKASA and Masao MAEDA

The magnetic aging phenomena were observed in electrodeposited Ni-Fe-P thin films. The saturation magnetization, AC hysteresis loop, coercive force, perpendicular anisotropy, uniaxial anisotropy and rotational hysteresis loss were measured and these results showed the aging effect. The activation energy of the rate of aging is found to be about 0.9 eV which seems to correspond to the value of the activation energy for the migration and annihilation of vacancy cluster in the films. The increase of demagnetizing effect due to the grain boundary was observed. It was found that the uniaxial magnetic anisotropy constant was reduced with time. According to the measurement of rotational hysteresis loss, this fact was explained as follows; the magnetization corresponding to the uniaxial anisotropy turns to the direction of large anisotropic magnetization induced in the surface region of film and the large part of anisotropy increases with time.

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5th International Congress on Metal-  
lic Corrosion (21-27th, May 1972,  
Tokyo)

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### **Corrosion Behavior of Iron and Low Carbon Steels in Molten Alkali Nitrates Containing Alkali Halide.**

Takenori NOTOYA, Tatsuo ISHIKAWA  
and Rinzo MIDORIKAWA

The oxidation behavior of iron and low carbon steels in molten alkali nitrates with or without potassium halide has been studied gravimetrically at 350°~470°C. Iron oxide scales grow parabolically in molten nitrate, while they grow linearly with time in the presence of halide. The corrosion rate of iron increases with increasing halide concentration and depends on the type of anions present in the melt, of which aggressiveness increases in the order,  $I^- < Br^- < Cl^-$ . Chemical analysis and EPMA measure-

ment indicate the presence of halide in the oxide layer. It is suggested that the corrosion behaviors of metals in the systems are similar to those of high-temperature corrosion in an oxidizing gas with or without halogen.

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5th International Congress on Metallic Corrosion. in Tokyo on 21-27 May, 1972

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### **Anodic Oxidation of Zirconium**

Takashi MOROZUMI and Makoto MORIYA

The anodic oxidation of zirconium was investigated by various electrochemical methods in aqueous solutions of ammonium nitrate and other electrolytes. In the potential region between 1.4 and 2.0 V. vs. S. C. E., the evolution of oxygen accompanied with the growth of oxide layer. In contrast, the growth of oxide layer predominated both in more noble and more basic potential regions. Rather peculiar phenomenon of the cease of oxygen evolution at high oxygen overpotential was explained by assuming that the electronic conduction by the tunnel mechanism controlled the rate of oxygen evolution on the passivated zirconium. The electron diffraction patterns of the anodic oxide films did not offer an adequate explanation of this phenomenon.

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The Fifth International Congress on Metallic Corrosion, Tokyo, Japan. May 21-27, 1972

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### **Thickness and Structure of Passive Films on Iron in Acidic and Basic Solution**

Norio SATO, Tetsuji NODA and Kiyokatsu KUDO  
Electrochemistry Laboratory, Corrosion Research Centre  
Faculty of Engineering

This paper describes the effect of solution pH on the passive film on iron which was investigated by ellipsometry and cathodic reduction in combination of chemical analysis. Anodic two-step passivation was employed to exclude anodic deposition of ferrous ion from anodic oxidation of iron. The film in acid solution is almost anhydrous oxide, whereas the film in neutral and alkaline solution has an outer hydrous oxide layer, whose thickness decreases with decreasing pH. The hydrated outer layer depends also on the anion present in solution. The transition layer model of the film is proposed to explain the results.

Conclusions drawn are as follows:

- (1) In the usual one-step passivation, an extra-growth of the passive film often

occurs as a result of the anodic deposition of hydrous ferric oxide from ferrous ion dissolved in the solution during the passivation.

(2) The two-step passivation can be used to obtain the passive film free of the extra-growth of hydrous oxide.

(3) The passive film formed by two-step passivation consists of an inner anhydrous oxide layer and an outer hydrous oxide layer.

(4) The thickness of the inner anhydrous oxide layer is determined mainly by the electric field existing in the layer.

(5) The outer hydrous layer depends on the solution pH and anion, and its thickness decreases with decreasing pH.

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5th International Congress on Metallic Corrosion (21-27th, May 1972, Tokyo)

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### **Application of High Speed Elongation Technique to Stress Corrosion Cracking of Fe-Cr-Ni Alloys**

Toshio SHIBATA\* and R. W. STAEHLE

Department of Metallurgical Engineering, Ohio State University, Columbus, Ohio, U.S.A.

A combined action of high anodic dissolution at the tip of a crack and the formation of protective film on the wall is assumed to be a necessary condition for the crack propagation in the alloy. A high speed elongation technique was applied to investigate this hypothesis. The current-time response at constant potential measures both a high initial peak and the reformation of a protective film. It was proved that the initial current density peak for alloys susceptible to SCC was high and the repassivation was rapid. The ratio of passive current density at a selected time to maximum current density was found to be a good parameter to correlate time to failure of the alloys in boiling  $\text{MgCl}_2$  solution. The effect of minor element on the SCC susceptibility of the alloys was discussed based on the model proposed.

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5th International Congress on Metallic Corrosion (21-27th May 1972, Tokyo)

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## **The Effect of an $\text{FeS}_2$ Layer on the Sulfide Scale Growth on Iron in Sulfur Vapor.**

Toshio NARITA and Keizo NISHIDA  
Metals Research Institute, Faculty of Engineering

Arrhenius plot of the sulfurization rate constant of pure iron showed two straight lines having the intersection at about  $700^\circ\text{C}$  under an atmospheric sulfur pressure. In order to reveal the mechanism of such a behavior the following basal reaction processes were carried out by using of markers: (a)  $\text{Fe}/\text{FeS}/\text{FeS}_2$ , (b)  $\text{FeS}/\text{FeS}_2/\text{S}_2(\text{g})$ , and (c)  $\text{Fe}/\text{FeS}/\text{S}_2$  (supplied by the equilibrium mixture of  $\text{FeS} + \text{FeS}_2$ ). From the experimental results obtained it was concluded that the overall behavior ( $\text{Fe}/\text{FeS}/\text{FeS}_2/\text{S}_2$ ) at lower temperatures came from the existence of pyrite as well as pyrrhotite scale on the surface of iron, differing from that on the higher temperature side where only pyrrhotite is formed. Moreover, the behavior at low temperatures was suggested to be controlled by the reaction (a), but the thin pyrite seemed only to separate pyrrhotite from sulfur vapor according to the theoretical consideration and experimental presentations. The disagreement found at low temperatures was also discussed.

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IUPAC, Symposium on Photo Chemical Processes in Polymer Chemistry  
Louvain, June 12-15, 1972

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## **Photo- and Radiation-Induced Ionic Polymerization**

Koichiro HAYASHI and Masahiro IRIE  
Division of Industrial Physical Chemistry

Photo-induced cationic polymerizations of styrene and  $\alpha$ -methylstyrene which are weak electron donors and contain no hetero atom, were carried out in the presence of electron acceptors such as tetracyanobenzene and pyromellitic dianhydride to elucidate the polymerization mechanism initiated through an excited charge transfer interaction.

Cyclohexene oxide was also polymerized by photoillumination in the presence of these electron acceptors. The mechanism of this ring-opening polymerization was thought to be a cationic one. Photo-polymerization of nitroethylene in tetrahydrofuran was carried out with the purpose of extending this process to anionic system. The results obtained have been compared with the cases of ionic polymerizations by ionizing radiation and conventional catalysts.

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Nobel Symposium No. 22, ESR  
Applications to Polymer Research,  
Stockholm June 20-22, 1972

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### **ESR Studies of Radiation- and Photo-Induced Ionic Polymerizations**

Hiroshi YOSHIDA, Masahiro IRIE  
and Koichiro HAYASHI

Division of Industrial Physical Chemistry

The nature of radical ions of styrene and  $\alpha$ -methylstyrene formed in  $\gamma$ -irradiated organic glasses was studied by electron spin resonance methods. Depending on the conditions, both radical cation and radical anion were found to be formed by charge transfer from glass matrix molecules to the solute monomers. In the presence of the radical cation, the polymer was obtained after warming the irradiated glasses. Radical anion was observed by electron spin resonance during the photolysis of  $\alpha$ -methylstyrene-tetracyanobenzene system (electron donor-acceptor complex). This gave an evidence that the triplet excited complex dissociates into ions, giving  $\alpha$ -methylstyrene radical cation.

These results, consistent with those by other techniques, showed that the radical cation of monomers is essentially important in the initiation process in both radiation- and photo-induced cationic polymerization of styrene and  $\alpha$ -methylstyrene. It is surveyed how the ESR technique contributed to and what are the limitations of this technique in the studies of the polymerization.

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Nobel Symposium No. 22, "ESR  
Application to Polymer Research"  
Stockholm, Sweden June 20-22, 1972

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### **ESR Studies on the Polymer Radicals Produced by Mechanical Fracture**

Junkichi SOHMA

From the ESR spectra observed from the mechanically-fractured polymers, such as polyethylene, polypropylene, and polytetrafluoroethylene, the radical species were identified. No ESR spectrum was observed from the solid of the low molecular compounds, such as benzene, ethanol and paraffin. It was found that the radicals produced by the fracture of the polymers are all the radicals formed from the scission of the carbon chain. Thus, it is the characteristic feature of the polymers that the macroscopic fracture of solid polymer at low temperatures causes the microscopic fracture of the polymer chain, that is the scission of the carbon chain. The other characteristics of the radicals produced by the mechanical fracture of the polymer were found to be the high reactivity with oxygen and the anomalous behaviors in the decay processes of the

polymer radicals. The molecular mechanisms of the fracture of the polymers were discussed on the basis of the facts established by ESR observation.

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IUPAC, International Symposium on  
Macromolecules, Helsinki, July 2-7,  
1972

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### **Spontaneous Polymerization of Nitroethylene- Isobutylvinylether System**

Mashiho IRIE, Nobuo KUSHIBIKI  
and Koichiro HAYASHI

Division of Industrial Physical Chemistry

The attempt to polymerize spontaneously isobutylvinylether and nitroethylene by the coexistence mechanism of cationic and anionic polymerizations was made. Optical absorption spectrum of the mixture of these monomers indicates the existence of a weak mutual interaction.

A spontaneous polymerization initiated by mixing these monomers was followed by gas chromatography and gravimetry. The product precipitated in ether was identified as a homopolymer of nitroethylene and the molecular weight was determined as  $[\eta] = 0.51$  in DMF.

A white needle crystal was separated at low temperature from ether soluble part of the reaction mixture and identified as 1:1 adduct of these monomers, that is, 2-nitro cyclobutyl isobutyl ether. Moreover, it was found that this adduct is capable to initiate an anionic polymerization of nitroethylene.

Then, the polymerizations of the adduct itself at various temperature were carried out and the activation energy of this polymerization was found to be 17.5 kcal/mol. The structure of polymer obtained was 1:1 alternative copolymer formed by ring opening cationic polymerization of the adduct.

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IUPAC, International Symposium on  
Macromolecules, Helsinki, July 2-7,  
1972

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### **Mass-Spectrometric Study on the Polymerization of Cyclic Monomers**

Koichiro HAYASHI, Minoru KUMAKURA\*,  
Kazuo ARAKAWA\*, Toshio SUGIURA\*  
and Akihiko ITO\*

Division of Industrial Physical Chemistry

The ion-molecule reactions of ethylene oxide, trioxane and ethylene oxide-trioxane mixture have been studied by means of a modified time of flight type mass spectrometer, since it is important to elucidate the active species and initiation mechanism of the radiation-induced ionic polymerization and copolymerization of these cyclic monomers.

In the mass spectra of ethylene oxide, neither dimer nor trimer ion is observed in the pressure range examined. It seems that this fact is related with the low polymerizability of ethylene oxide by ionizing radiation.

The main primary ions of trioxane  $m/e$  29, 31, 61, 89 and 90. It was found that the secondary ion 91 is produced by proton transfer reaction of 89 ion with trioxane and 119, 121, 151 ions are formed by the ion-molecule reaction of primary ions. These secondary ions demonstrate a maximum intensity as a function of reaction time owing to the successive reactions. The rate constants of these reactions correspond to the propagation rate constants of radiation-induced gas phase polymerization in the earlier stage and were estimated from the pressure and reaction time dependence independently.

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Presented at the International Symposium on Physics and Chemistry of Ice held in Ottawa, Canada from 14th to 18th August, 1972

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### **Stacking Fault Images in $\text{NH}_3$ -Doped Ice Crystals Revealed by X-Ray Diffraction Topography**

Mitsugu OGURO and Akira HIGASHI

Department of Applied Physics, Faculty of Engineering

X-ray diffraction topographs were taken to observe stacking faults in ice single crystals grown from dilute aqueous solution of ammonia. The stacking faults extended very widely on the basal plane and their fault vector was determined by contrast effects with  $(10\bar{1}0)$ - and  $(11\bar{2}0)$  diffraction planes. Both Heidenreich-Shockley type with  $\frac{1}{3}\langle 10\bar{1}0 \rangle$

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\* Takasaki Radiation Chemistry Research Establishment, Japan Atomic Energy Research Institute, Takasaki, Gumma.

Burgers vectors and Shockley-Frank type with  $\frac{1}{6}\langle 20\bar{2}3 \rangle$  were found. The large stacking fault is explained by the decrease of stacking fault energy caused by adsorption of impurities on the fault. Aging effects and other special features of stacking faults were described.

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Presented at the International Symposium on Physics and Chemistry of Ice held in Ottawa, Canada from 14th to 18th August, 1972

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## Electric Charges Associated with Dislocations in Ice

Akira HIGASHI and Yoshihiko TERAMOTO

Department of Applied Physics, Faculty of Engineering

Electric charges associated with newly introduced dislocations in ice single crystals by plastic deformation were quantitatively measured. A measuring method using surface potentiometer to detect charges conveyed to the specimen surface with dislocations was described. Increasing rate of charges with time was found to be proportional to the strain rate and the proportional constant gives the amount of generating charge per unit strain. The amount of charge per unit length of single screw dislocation in ice was calculated from this constant as  $8.8 \times 10^{-16}$  coulomb $\cdot$ m $^{-1}$  in minus sign. Origin of the charges is attributed to dislocation jogs which produce and capture OH $^{-}$  ions in ice.

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Ninth International Congress of Crystallography Kyoto, Japan. 26 Aug.-7 Sep. 1972

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## Lattice Distortions and Crystallite Sizes in the Chain Direction of Polyoxymethylene

Akira ODAJIMA, Shigeru YAMANE and Teruo ISHIBASHI

Department of Applied Physics, Faculty of Engineering

and

K. DOI

Japan Atomic Energy Research Institute

The characteristics of the lattice distortions in the chain direction and the distribution of the lamella thicknesses for hot-drawn samples of polyoxymethylene (POM) are investigated. To separate distortion and size broadening of a x-ray line profile, the Fourier-transform method (FTM) as well as the integral breadths method (IBM) are applied to the profiles of the (009) and (0018) reflections of POM, after instrumental

broadenings are adequately corrected. The FTM analyses show that both the paracrystal- and strain-type distortions exist for the as-drawn specimen, while the strain-type distortion is remarkably diminished when the specimen is annealed above 150°C. While the IBM based on the paracrystalline theory gives only one parameter of the lattice distortion, or the degree of disorder, in any cases. It is found that the degree of disorder obtained by the IBM is in considerably good agreement with that obtained by the FTM for some of annealing samples. However, for a sample annealed at temperature near the melting point, the homogeneous paracrystalline distortions in the chain direction is found to be unrealized.

The number- and volume- average crystallite sizes,  $\bar{D}_n$  and  $\bar{D}_v$ , are obtained by the FTM and  $\bar{D}_v$  is also obtained by the IBM. By using the relation between  $\bar{D}_n$  and  $\bar{D}_v$ , the statistical dispersion of the lamella thickness,  $\bar{D}_n^2 - \bar{D}_n^2$  is determined and it is found that  $\bar{D}_n^2 - \bar{D}_n^2$  increases with annealing temperature, while  $(\bar{D}_n^2 - \bar{D}_n^2)^{1/2} / \bar{D}_n$  decreases with annealing temperature. Finally the lamella thickness is compared with the long period found by small angle x-ray scattering.

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Ninth International Congress of Crystallography. Kyoto, Japan. 26 Aug.-7 Sep. 1972

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## Lattice Dynamics of Trigonal Selenium

T. NAKAYAMA, Y. IKEDA  
and Akira ODAJIMA

Department of Applied Physics, Faculty of Engineering

A valence-force-field (VFF) model is applied to the lattice dynamics of trigonal selenium. By using the method of long waves due to Born and Huang, five adjustable parameters, e.g., four valence-force-constants (VFC),  $K_r$ ,  $K_\theta$ ,  $K_{r'}$  and  $K_{r\theta}$ , within intra-chain couplings and one inter-chain force constant  $K_R$  between the nearest neighbour atoms on adjacent chains, are determined from the observed six independent elastic constants ( $c_{\ell j}$ ) by means of the least squares method. Each of the VFC's for the helical chain of Se is somewhat less than corresponding one for the ring molecule of  $\text{Se}_8$ . The  $\Gamma$ -point optical frequencies are calculated in terms of these force constants. They are 236, 49, 234 and 146  $\text{cm}^{-1}$  for the  $A_1$ ,  $A_2$ ,  $E_1$  and  $E_2$  modes, which are in good agreement with the observed values of 237, 234 and 146  $\text{cm}^{-1}$  for  $A_1$ ,  $E_1$  and  $E_2$  modes except that for the  $A_2$  rotational mode which is 103  $\text{cm}^{-1}$ . However, the last can be also accounted for well if the contribution of about 50  $\text{cm}^{-1}$  is taken into consideration. The estimation for the above contribution seems reasonable from the view-point of the shell-model analysis due to Chen and Zallen (Phys. Rev. (1968) **173**, 833). Furthermore attempts are made to explain the dispersion relations of trigonal selenium obtained recently from the neutron inelastic scattering measurement.

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Presented at IXth International Congress of Crystallography held in Kyoto, Japan, from 26th August to 7th September, 1972

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## Dynamical Behavior of Dislocations in Ice Crystals

Akeharu FUKUDA and Akira HIGASHI

Department of Applied Physics, Faculty of Engineering

The velocity of individual dislocation in the single crystals of ice subjected to the various stress was measured from the X-ray diffraction topographs taken intermittently among every loading. It was found that the velocity  $v$  is proportional to the stress  $\tau$  in the range of shear stress between 0.5 and 3.0 kg/cm<sup>2</sup>. The proportional constant  $c$  in the equation  $v=c\tau$  differs from  $7.8 \times 10^{-5}$  to  $3 \times 10^{-5}$  cm<sup>3</sup>·kg<sup>-1</sup>·sec<sup>-1</sup> according to the nature of dislocations. The results assures the linear relationship in wider stress range when they were combined to those hitherto obtained directly or indirectly.

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Nineth International Congress of Crystallography Aug. 26-Sept-7, 1972  
Kyoto, Japan. Session 75 X-ray diffraction line profile analysis

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## X-ray diffraction peak shift due to stacking fault in single crystals of Cu-Ge alloy

Shin'ichi SATO, Toshihiko TAKAMA  
and Norikatsu YOKOTA

Department of Applied physics

X-ray oscillation photographs were taken for deformed single crystals of Cu-11wt% Ge alloy. Sharp spots,  $M$ , and diffuse streaks with intensity maxima,  $S_1$  and  $S_2$ , were observed on the film corresponding to unfaulted and faulted regions in the specimen, respectively. The observed streaks were translated into the intensity curves in the usual way by using a micro-densitometer. Corrected intensity profiles have been compared with the theoretical ones for the various stacking faults in f.c.c. crystal. The following conclusions have been drawn by the comparison. (1) The faulted regions contain very large amounts of stacking fault. (2) The  $S_2$  diffuse maxima can not be interpreted by Paterson's theory where the "Reichweite"  $s=1$  is assumed, and also not by Wilson's theory where the stacking sequence is assumed to be equivalent to its twinned counterpart. (3) To understand these maxima  $S_2$ , with  $S_1$ , the  $s=2$  stacking fault, with two fault probabilities,  $\alpha_1$  and  $\alpha_2$ , proposed by Kakinoki, must at least be in consideration. (4) A calculated intensity curve for  $\alpha_1=0.5$  and  $\alpha_2=0.1$  gives the best fit on an experimental profile.

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International Symposium on Stratified Flows, Novosibirsk, IAHR and the Academy of Science, USSR, Aug. 29-31, 1972

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## **Flow Pattern at a River Mouth**

Masakazu KASHIWAMURA

Professor of Engineering Mechanics

and

Shizuo YOSHIDA

Research Assistant of Engineering Mechanics

When the surface velocity is measured in the vicinity of a river mouth, large values in velocity are sometimes found at some unexpected places on the sea. This can be understood, by the following reasons, as a phenomenon brought by a property of the density current.

As already published, the surface flow at a river mouth usually has various kinds of flow pattern, in response to a degree of the river discharge.

It was newly revealed, in any pattern, that the surface velocity on the midstream accelerates itself transiently, outside the mouth, due to the effect of buoyancy caused by the density difference of the fresh water and the sea water.

In addition, another type of acceleration was also found at both corners of the mouth. Thus the distribution of the surface velocity appears to be complicated with such two types of acceleration.

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6th International Biometeorological Congress held at Noordwijk, The Netherlands, 3-10 September, 1972

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## **A rational method to measure radiant temperature and air motion to evaluate human comfort**

Kan-ichiro IBAMOTO

Faculty of Engineering

An accurate measurement of all environmental variables concerned has great significance in judging comfort and thermal sensation and in predicting the body heat exchange. The proposed instrument is consisted of a pair of circular cylinders, one of which is heated electrically and the other is unheated. Temperature sensors are built in both cylinders and connected to an indicator. The difference of temperature readings can be directly related to the convection coefficient, when the two constants, i.e., a rate of heat supply and a radiation coefficient are fixed. By applying heat transfer theory,

the relation between the convective heat transfer coefficient and the traverse air velocity over a cylinder is substituted to derive the rate of the ambient air motion. The mean radiant temperature is also obtained and that essentially includes the shape factor between a cylinder and surroundings, supposing a human body to be a cylinder rather than a sphere.

In addition to the environmental thermometry the indication can be applied to predict human comfort, i.e., the heated cylinder itself is assumed to be a scaled down model of a human body, since appropriate proportionality factors are substituted in designing the instrument.

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Second International Symposium in  
Hydrology, Fort Collins, Colo., U.S.A.  
Sep. 11-13, 1972

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### A Simulation Technique of Monthly Runoff by Use of Precipitation Time Series at Multistations

Kiyoshi HOSHI and Isao YAMAOKA

This paper proposes a simulation technique of monthly precipitation which is an alternate to the often used Markov model. In the simulation method presented use is made of the interrelationships between the monthly precipitation events at a key station, matrix  $X$ , and at satellite stations, matrix  $Y$ , which is represented by the matrix equation

$$Y = AX + BE$$

where  $E$  is a random component and  $A$  and  $B$  are coefficient matrices. Synthesizing the monthly precipitation by this matrix equation has the advantage that the relevant information between the satellite stations is utilized with the consequent reduction in the random component. The areal precipitation of the basin for the several months is designated by the vector  $P$ , which is related to the matrix  $Z$  of standardized rainfall at the station by the matrix equation

$$P = WZ$$

where  $W$  is a coefficient vector corresponding to the raingage stations. The coefficient vector  $W$  is shown to be related to the eigen value, and the eigen vector of the correlation matrix between the stations.

The simulation model used for generating simultaneously the runoff at several stations is

$$Q(I) = AP(I) + BP(I-1) + CP_a + DE(I)$$

where the  $Q(I)$  is the matrix of the runoff events of the  $I$ th month,  $P(I)$  and  $P(I-1)$  are the areal precipitations at times  $I$  and  $I-1$ , and  $P_a$  is a matrix representing the precipitation accumulated during the winter season (November to February), which is important where snowmelt provides a major portion of runoff during the spring season. Monthly runoff at given stations is thus synthesized from the precipitation inputs on the watershed.

The methodology was tested on the Ishikare River basin, Hokkaido, Japan. Monthly

precipitation and runoff were synthesized for a period of 79 years, which is the duration of the record at the key station. The existing records were normalized by means of a square root transformation of the rainfall data and a log Pearson Type III transformation of the runoff data. The statistical properties of the generated were found to be consistent with those of the observed data.

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CIB commission W 45 Symposium  
 "Thermal Comfort and Moderate  
 Heat Stress" held at Building Re-  
 search Establishment, Department of  
 Environment, Watford, England. 13-  
 15 September 1972

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### **Standard effective temperature - a single temperature index of temperature sensation and thermal discomfort**

A. P. GAGGE, Y. NISHI\*  
 and R. R. GONZALEZ

John B. Pierce Foundation Laboratory and Yale University,  
 New Haven, Connecticut, U.S.A.

Standard Effective Temperature (SET) is a rationally derived temperature index of man's thermal environment based on the physics of man's heat exchange, and his physiological and psychological responses. SET is directly related to Standard Operative Temperature and describes the dry bulb temperature of a standard environment at 50% relative humidity which causes the same radiation, convection and evaporative heat exchange as in the actual environment.

The Standard Effective Temperature is related numerically to our own everyday experience, and more than likely corresponds to the temperatures we know familiarly as 'hot', 'warm', 'pleasant', 'cool' and 'cold', and to our sense of warmth, cold and comfort, when we read a dry bulb thermometer in our homes. In warm environments ( $SET > 25^{\circ}\text{C}$ ) the sense of discomfort increases apporoximately with the square of the difference ( $SET - 23^{\circ}\text{C}$ ) while the sense of temperature increases linearly with SET. In the cold the sense of discomfort and temperature vary linearly with SET as well as with the mean skin temperature.

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Presented at the International Symposium on the Environment in Buildings held at University of Technology, Loughborough, Leicestershire, England. September 18th-22nd, 1972

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## **Warmth Diagram for Thermal Sensation Analysis and Its Application in Environmental Design**

Kan-ichiro IBAMOTO and Tohru MOCHIDA  
Faculty of Engineering

A Warmth Diagram is proposed as an index of thermal sensation and for environmental assessment based on a rational heat balance equation which describes both physical and physiological human responses. The Diagram is applied to predict thermal sensation at any unexperienced environment from an integrated assessment of six important environmental variables concerned namely, ambient air temperature, mean radiant temperature, humidity, air movement, metabolic rate and clothing worn. The four main channels of heat exchange are analyzed from an engineering angle. For the respiration process heat loss is finally expressed in terms of ambient air conditions and metabolic rate. For the heat loss by skin evaporation besides mass transfer equation to describe sweat evaporation a new model of cutaneous layer is proposed, i.e., a model has thermo-receptor to receive temperature signal which affected by both environmental and physiological stimuli and the rate of sweat secretion or wet area ratio is regulated by its temperature level. A characteristics of a proposed model is verified by comparing calculated values with physiological data observed on many experiments. Since a certain combination of thermo-receptor temperature and mean skin temperature is supposed to give the same temperature sensation, lines of equal temperature sensation can be drawn based on heat balance equations derived. The Warmth Diagram proposed is prepared for some relevant combinations of variables concerned, namely, clothing insulation, metabolic rate and air movement in the uniform temperature field.

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Presented at the International Symposium on the Environment in Buildings held at University of Technology, Loughborough, Leicestershire, England. September 18th-22nd, 1972

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### **A Rational Heating Design for a Man-Comfort-Thermal System**

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A rational method of heating design is proposed on the basis of our newly proposed thermal sensation index, namely Warmth Diagram. The Warmth Diagram is derived from bio-physical heat balance equations between man and his environment and applied to the assessment of thermal system of the environment. Six main environmental variables dealt with include ambient air temperature, mean radiant temperature, humidity, air motion, clothing worn and metabolic rate. A unique optimum condition to be realized is derived when a steady state thermal characteristics of a building and a comfortable thermal condition can be simultaneously met with. In another words an intersection of two lines, which represent numerous combinations of both indoor climate and comfortable condition, on the same co-ordinate is an only desirable condition to be realized. As practical examples the design method of both radiant and warm air heating are discussed and compared with a conventional method.

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### **Optical Heterodyne Processing for Atmospheric Turbulence with Two Ultrasonic Light Modulators**

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The use of double diffraction of a coherent light wave, produced after passage through a pair of ultrasonic light modulators (ULM), has been suggested for optical heterodyne detection processing. A beat signal can be generated with a difference or

sum frequency between the two sound frequencies, when a pair of diffracted light beams of the first order in each ULM in the double diffraction spectrum are photomixed on a square-law detector. It is remarkable that this system requires no optical components except the two ULM's and moreover its alignment is not critical for optical heterodyning. As an application of this system it is predicted analytically and confirmed experimentally that a probability density function for the phase fluctuations of the beat can be given by processing the perturbed beat signals electronically.

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### Multiple Relaxation in $\alpha$ - and $\gamma$ -Loss Bands of Polyethylene

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Dielectric and NMR behaviors of linear polyethylene are observed in the  $\alpha$ - and the  $\gamma$ -loss bands to investigate the nature of the multiple loss patterns of these loss bands. The results obtained are compared with those of mechanical measurements. In the dielectric behavior of the oxidized linear polyethylene three relaxations are found in the  $\gamma$ -loss band, while only one relaxation is found in the  $\alpha$ -loss band. The  $\beta$ -relaxation is found as a plateau region between the  $\alpha$ - and the  $\gamma$ -loss bands. The loss pattern of the  $\alpha$ -loss band is different from that for the mechanical case which is composed of three relaxations. The effects of difference in morphology, addition of diluent and heat-treatment on the multiple loss patterns are examined. The results suggest that there are two non-crystalline parts in the outside region of lamella including lamellar surfaces and the two modes of molecular motion in each of these parts are responsible for each pair of relaxation; of the three relaxations found in the  $\gamma$ -loss band the  $\gamma_2$ -relaxation is related to the dielectric  $\alpha$ -relaxation, while the  $\gamma_1$ -relaxation is related to the  $\beta$ -relaxation. The relation between the two relaxation in each pair is similar to that between the primary relaxation and the local mode relaxation of amorphous polymers which are caused by the same molecules. The  $\gamma_3$ -relaxation seems to be caused by some different mechanism.